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Research during this period has concluded in (1) the revision of the lattice of the Duke FEL ring to suppress magnetic saturation effects, (2) the installation of the major magnetic components for the ring, and (3) the development of a new concept for the production of coherent 40-50 Å light using "phase-displacement" deceleration.

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The principal milestones scheduled for this period were:

1. The completion, installation and initiation of operation of a prototype of UV undulator on the 1 GeV FEL Ring.

2. Fabrication and installation of a synchrotron radiation beamline on ring.

3. Fabrication and installation of an optical resonator on the ring capable of operating at full power in the ultraviolet.

These milestones were modified to account for (A) a six month delay in the completion of the new FEL laboratory building (to 15 January 1991), (B) problem in the magnetic shielding developed in the prior contract period to limit the saturation of the ring dipole and sextupole magnets, and (C) the emergence of the new physical approach to the attainment of FEL operation in the 40-50 angstrom region.

As a consequence of these developments, research during this period was redirected toward two revised milestones:

1. The redesign of the FEL ring to eliminate the descrete sextupole magnet whose position (immediately next to the dipole bending magnets) had been the cause of the problems with saturation.

2. Redesign of the undulator system for the use of the "Phase-displacement" lasing mechanism in 40-50 angstrom region.

The third objective, the design and installation of a bend-magnet synchrotron radiation port, was deferred pending completion of the basic experimental facilities in the new laboratory building.

Redesign of the FEL Ring Lattice:

The elimination of the discrete sextupole which had previously been located between the dipole magnet and the adjacent quadrupole focusing magnets eliminated the saturation problems which had previously compromised both the sextupole and dipole magnets. An equivalent sextupole filed was

introduced through the asymmetric excitation of the remaining quadrupole magnets.

Following confirmation of the success of this approach, all the associated mounting and alignment hardware for the magnets was modified to allow for the changes in the positions of the magnets and installation of the magnets was begun.

Analysis of Phase-displacement amplification:

Careful study of the Phase-displacement amplification mechanism reviewed by Kroll, Morton and Rosenbluth has indicated that megawatt level peak powers and good transverse and temporal coherence can be obtained using a high field spontaneous radiator to drive a weakly tapered phase-displacement amplifier.

Study of the parameters of this system were continued through the contract period to determine the most favorable operating conditions.

Other activities:

Installation of those components of the system whose configuration was not altered by the design changes to the lattice of the ring continued though the conclusion of the contract period. The most important efforts were directed toward the procurement and installation of the cooling system and high power RF systems for the FEL ring.